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ABSTRACT TITLE: The use of Piezoelectric Resonators for the Characterization of Mechanical Properties of Polymers

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ABSTRACT TEXT

In this paper a variety of techniques to characterize the mechanical properties of polymers in the MHz frequency range based on the impedance analysis of thickness and thickness shear composite resonators will be presented. The analysis is based on inverting the impedance data of the composite resonator to find the best fit using the material constants of the piezoelectric resonator and attached polymer layer. Mason's equivalent circuit is used along with standard acoustic circuit elements to generate the impedance of the composite resonators and interpret the experimental data. Inversion techniques will be presented which allow for the direct determination of the acoustic load if the material properties of the resonator are known before being joined to the polymer.

A specific example of this technique, the quartz crystal microbalance will be presented and it will be shown how the model can be extended to include all the acoustic elements of the experimental setup including the acoustic load of the solution. In the model all elements are treated as complex to account for loss mechanisms (viscous effects, electric dissipation etc.). If the free resonator is modeled prior to deposition a transform is presented that allows for the determination of the acoustic load directly. The advantage being that one no longer has to assume a functional form of the acoustic load (eg. mass damping) since it can be measured directly and compared to the various models. In addition the transform allows for an easy determination of the mass sensitivity and bandwidth for the system. The theory can be extended to account for electrode mass or the addition of a chemically sensitive layer for use in chemical monitoring. The technique has applications in monitoring deposition rates, curing rates of epoxies, glues as well as the direct determination of the elastic constants of polymer materials.

KEYWORDS: Piezoelectric devices, Active Materials, Thin Film Resonators, Composite Resonators, Quartz Crystal Microbalance.

BRIEF BIOGRAPHY: Dr. Stewart Sherrit joined the JPL's NDE& Advanced Actuators (NDEAA) in Sept. 1998. He is working on the development of finite element and analytical models of novel actuator mechanisms. Dr. Sherrit received his B.Sc., M.Sc. and Ph. D. all in engineering physics from Queen's University, Kingston. Prior to joining JPL he worked in the Applied Solid State Research Group at Queen's as a research engineer involved in thin film piezoelectric and ferroelectric devices. In 1988 he moved to the Physics Department at the Royal Military College of Canada where he was involved in developing new techniques to characterize electromechanical materials. He has authored over 40 papers in the field of electromechanical materials and has been invited speaker at international meetings.